FERMILAB-UPC-172

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December 6, 1983

SEXTUPOLE COMPONENT b_2 OF DOUBLER DIPOLES AT LOW FIELDS

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This note is a hurried attempt to collect all the available data on the normal sextupole component b_2 of the dipoles at below the Tevatron injection field (corresponding to 660A). As such, the speed was the only consideration and not much thinking went into it. The only document on this subject has been

UPC #162 B. Brown, "HYSTERESIS EFFECTS ON SEXTUPOLE MOMENTS OF TEVATRON DIPOLES AT INJECTION CURRENT"

Yesterday, Dec. 5, he issued another one:

UPC #171 B. Brown, "Saver Dipole Persistent Current Hysteresis Effects".

People interested in learning this subject should read these two reports before reading the present one.

Around March of '81, we decided to drop the harmonic measurement at 200A. As a consequence, there are less than thirty dipoles for which the data on b_2 at 200A are available in the public database (CYBER files). In 1982, for reasons I do not quite understand, seven dipoles were measured at 200A in addition to the regular high currents. These may have been used for some special purposes with different ramping. There are some indications that these dipoles should be treated separately from others which were measured before the spring of '81. It is also true that the measurements in '80 were perhaps less reliable for the low field b_2 because of possible undershoot or overshoot of the current. The value of b_2 at 200A is very sensitive to this type of error. Because of this possibility, one might take only seven dipoles measured in '82 as something totally reliable. All these points should be carefully weighed under the normal circumstance but this unfortunately is not possible now. Data are therefore presented with the minimum amount of comeents; people using the data should be well aware of the potential danger in doing so.

Table 1 lists all magnets for which 200A data on b_2 are available. As one can seee from Table 2, values of b_2 are quite scattered. Currents in amperes are qualified further by the symbol ↑ or ↓ indicating whether the current was increasing or decreasing. The column marked "body" is for the field in the center of magnets while "total" includes effects of two ends. Clearly ends make large negative contribution to the total sextupole component. Table 3 is perhaps more useful for our immediate purpose (SSC workshop, deceleration in the doubler); The first line, for example, gives the average and the std.dev. of the quantity $b_2(200A\uparrow) - b_2(500A\uparrow)$ for 31 magnets. These quantities scatter much less than the ones given in Table 2. Table 4 is simply taken from UPC #162 and UPC #171. Results in Table 4 genrally agree well with those in Table 3. However, there is an indication that, in Table 3, $b_2(200A\downarrow)$ is somewhat overestimated. For example, from Table 3, we have $b_2(660A\uparrow) - b_2(200A\downarrow) = -31.8$ while Table 4 indicates 15.55 - 43.8 = -28.3. This tendency is clear also from Table 5 where b_2 at each current is given for the seven dipoles measured in '82. For three magnets for which data are available, we have

TC 403	$b_2(660A\uparrow) - b_2(200A\downarrow)$	= -22.8
TC 778		= -24.4
TC1038		= -23.2

Perhaps it is true that $b_2(200A\downarrow)$ is overestimated in Table 3 by 3 to 5 but this is little more than a speculation. Table 6 lists all the data on b_2 used for the present report. These include sextupole contributions coming from ends as well as the body of magnets.

Table 1. Measured magnets (* = in the tunnel)

magnet ID	meas. series	meas. date
TA 257	4	810311
TB 310	4	810313
TB 329*	5	800921
TB 332*	2	800917
TB 335*	2	800920
TB 342	3	800924
TB 343*	4	800822
TB 345*	1	800802
TB 348*	1	800723
TB 351*	1	800822
TB 356*	3	800811
TB 358	1	800816
TB 359*	2	800729
TC 361*	3	801029
TB 363*	1	800923
TB 368	2	800915
TB 369*	2	800919
TB 370*	3	800911
TB 371*	2	800917
TB 374	1	800830
TB 375*	2	800905
TB 380*	2	800920
TC 393*	3	810317
TC 403*	3	820903
TC 411*	4	810222
TC 435	3	810220
TC 451	4	810217
TC 488*	3	810314
TC 689*	5	820728
TC 778*	2	821215
TC 971*	3	820810
TB1028*	3	820804
TC1029*	3	820805
TC1038*	2	820827

Table 2. b_2: average and std. dev. (in 10^{-4} at 1")

	body		total		no. of samples
200A↑	-11.4	±6.3	-25.7	±5.8	34
500A↑	10.3	4.8	- 4.3	4.6	31
660A↑	13.8	4.3	- 0.8	4.1	30
660A↓	24.0	4.3	9.6	3.7	30
500A↓	26.8	3.3	12.2	2.9	28
200A↓	44.2	6.4	30.0	6.0	34

Table 3. Variation of b_2: average and std.dev. (in 10^{-4} at 1")

		body		total		no. of samples
200A↑	- 500A↑	-21.1	±2.2	-20.9	±1.9	31
200A↑	- 660A↑	-24.4	2.5	-24.1	2.2	30
660A↑	- 660A↓	-10.3	2.1	-10.5	1.1	30
660A↑	- 500A↓	-13.0	0.7	-13.3	0.6	27
660A↑	- 200A↓	-31.6	3.5	-31.8	3.0	30
660A↓	- 500A↓	- 2.8	1.6	- 2.6	0.7	27
660A↓	- 200A↓	-21.3	2.2	-21.4	2.2	30
500A↓	- 200A↓	-19.2	1.9	-19.4	1.3	28

Table 4. From UPC #162 (B. Brown), TB 349

I(A)	0	200↑	660↑	4000 (max.)	660↓	400 (min.)	660↑	4000 (max)	660↓	400↓	200↓	
b_2	-9.00	15.55	19.5	24.6	29.1	15.5	19.5	24.6	29.3	43.8		(1", 10^{-4})

From UPC #171 (B. Brown), TC 535

I	660A↑	660A↓	diff.
b_2	6.59	17.10	10.5 (1", 10^{-4})

Table 5. Magnets measured in 1982

	200A↑	500A↑	660A↑	660A↓	500A↓	200A↓
TC 403	-14.4	2.4	5.0	13.7	---	27.8
TB 689	-32.7	-9.7	---	---	6.1	17.0
TC 778	-35.1	-12.8	-9.4	1.5	---	15.0
TC 971	-33.6	---	---	---	---	18.5
TB1028	-32.0	---	---	---	---	30.9(?)
TC1029	-26.2	---	---	---	---	22.0
TC1038	-29.9	-6.1	-2.7	7.8	---	20.5

Table 6. Data on b_2 used in this report.

magnet	200A↑	500A↑	660A↑	660A↓	500A↓	200A↓
257	-31.1	-11.8	-8.2	1.1	3.6	21.8
310	-23.3	- 2.2	1.0	11.5	13.9	33.9
329	-24.5	- 3.5	0.0	10.6	12.7	32.2
332	-23.8	- 0.9	2.7	13.2	15.3	33.2
335	-25.3	- 4.9	-1.8	8.5	10.7	30.0
342	-23.0	- 1.4	2.1	12.5	14.6	32.7
343	-25.7	- 5.4	-2.3	8.3	10.8	30.7
345	-23.4	- 3.3	-0.1	10.3	12.5	30.8
348	-22.4	- 0.8	2.5	13.2	15.6	34.9
351	-21.8	- 1.6	1.7	12.3	14.6	33.2
356	-24.3	- 4.3	-0.9	10.2	12.3	31.7
358	-20.1	- 0.2	3.1	13.6	16.2	35.9
359	-22.7	- 4.2	-1.0	9.2	11.6	30.8
361	-20.2	- 0.6	2.8	13.6	16.1	36.5
363	-26.9	- 5.5	-2.0	8.8	11.3	31.4
368	-18.3	0.2	3.3	14.0	16.5	36.7
369	-22.2	- 1.1	2.2	13.5	16.0	36.9
370	-23.1	- 1.7	1.8	12.7	15.2	35.0
371	-22.6	- 3.4	-0.1	10.5	12.8	32.2
374	-26.6	- 4.8	-0.6	6.3	11.9	26.8
375	-26.3	- 3.2	0.2	10.2	12.6	34.8
380	-26.2	- 6.5	-3.3	7.6	10.1	30.4
393	-14.6	5.1	6.3	14.0	17.5	35.3
403#	-14.4	2.4	5.0	13.7	---	27.8
411	-21.1	-3.2	-0.3	10.8	13.8	36.8
435	-34.7	-11.8	-8.3	3.2	5.7	26.2
451	-38.4	-15.9	-13.2	-0.7	2.3	25.1
488	-36.6	- 9.7	-5.6	6.9	9.5	31.2
689#	-32.7	- 9.7	---	---	6.1	17.0
778#	-35.1	-12.8	-9.4	1.5	---	15.0
971#	-33.6	---	---	---	---	18.5
1028#	-32.0	---	---	---	---	30.9
1029#	-26.2	---	---	---	---	22.0
1038#	-29.9	- 6.1	-2.7	7.8	---	20.5

#: measured in 1982.

UPC No. 172A

December 6, 1983

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ADDENDUM to UPC No. 172

I have unearthed more data on b_2 at low fields. It now seems clear that, for some reasons unknown to me, values of b_2(200A↓) measured in '80 and '81 were overestimated by 6 to 7 units compared to values measured in '82.

Body field only

		'80 & '81		'82	
200A↑	- 500A↑	-21.1	±2.1	-21.8	±3.4
	- 660A↑	-24.4	2.4	-25.1	3.8
	- 660A↓	-34.7	3.0	-35.7	4.6
	- 500A↓	-37.4	2.7	---	
	- 200A↓	-56.9	3.6	-50.7	7.5
660A↑	- 660A↓	-10.3	2.2	-10.6	0.9
	- 500A↓	-13.0	1.0	---	
	- 200A↓	-32.5	3.0	-25.7	4.5
660A↓	- 500A↓	-2.8	1.6	---	
	- 200A↓	-22.2	1.5	-15.0	3.8